

Graphing Motion: Position or Distance

- When graphing the position of an object or distance traveled as a function of time, the slope at any point on the curve gives the velocity.
- See applet demo.

A quantity that is a measure of how the velocity of a body changes with time is:

- A. Displacement.
- B. Speed.
- C. Acceleration.
- D. Momentum

The acceleration of a body must be zero at a point where

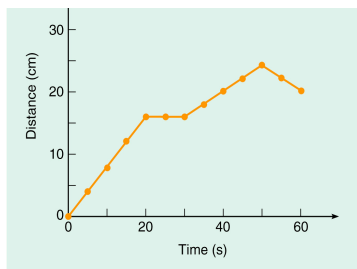
- A. the instantaneous velocity is zero but changing.
- B. the instantaneous velocity is not zero but changing.
- C. the instantaneous velocity is constant.

In a speedometer test zone on a highway, you drive 5 miles in 6 minutes. During the test, your speedometer reading is 55 mi/hr. Your speedometer reading is

- A. lower than your actual speed.
- B. equal to your actual speed.
- C. higher than your actual speed.

Graphing Motion: Distance

time	position
0s	0cm
5s	4.1cm
10s	7.9cm
15s	12.1cm
20s	16.0cm
25s	16.0cm
30s	16.0cm
35s	18.0cm



- Draw horizontal and vertical axis
- Draw dots for each of the time-position measurements

Graphing Motion: Calculate Velocity

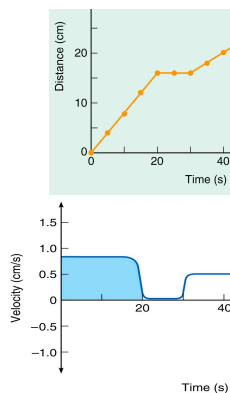
time	position	velocity
0s	0cm	0.8m/s
5s	4.1cm	0.8m/s
10s	7.9cm	0.8m/s
15s	12.1cm	0.8m/s
20s	16.0cm	0.0m/s
25s	16.0cm	0.0m/s
30s	16.0cm	0.4m/s

$$\text{Velocity} = \frac{\text{change in position}}{\text{elapsed time}}$$

$$\text{velocity} = \frac{d_{\text{final}} - d_{\text{initial}}}{\text{elapsed time}}$$

Graphing Motion: Velocity

time	position	velocity
0s	0cm	0.8m/s
5s	4.1cm	0.8m/s
10s	7.9cm	0.8m/s
15s	12.1cm	0.8m/s
20s	16.0cm	0.0m/s
25s	16.0cm	0.0m/s
30s	16.0cm	0.4m/s
35s	18.0cm	



Graphing Motion: Calculate Acceleration

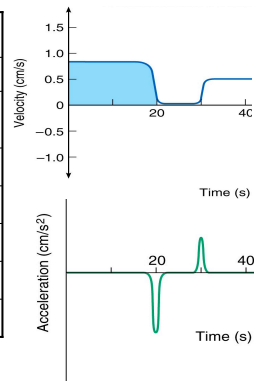
time	velocity	acceleration
0s	0.8m/s	0m/s ²
5s	0.8m/s	0m/s ²
10s	0.8m/s	0m/s ²
15s	0.8m/s	0m/s ²
20s	0.8m/s	0.2m/s ²
25s	0m/s	0.0m/s ²
30s	0m/s	

$$\text{Acceleration} = \frac{\text{change in velocity}}{\text{elapsed time}}$$

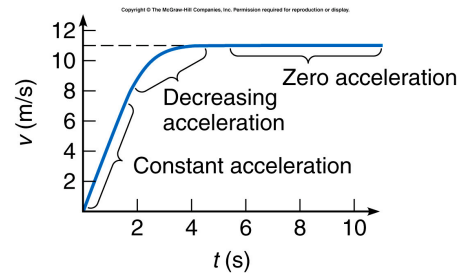
$$\text{Acceleration} = \frac{v_{\text{final}} - v_{\text{initial}}}{\text{elapsed time}}$$

Graphing Motion: Acceleration

time	velocity	acceleration
0s	0.8m/s	0m/s ²
5s	0.8m/s	0m/s ²
10s	0.8m/s	0m/s ²
15s	0.8m/s	0m/s ²
20s	0.8m/s	0.2m/s ²
25s	0m/s	0.0m/s ²
30s	0m/s	



Interpreting Graphs



- Acceleration = slope of velocity graph
- Larger slope \Rightarrow larger acceleration

Types of Motion

- Constant Velocity:
 - Equal distance covered in equal time intervals
- Constant Acceleration:
 - Equal increments of speed gained in equal time intervals
 - Distance increases in each time interval (see demo)

Constant Acceleration (I)

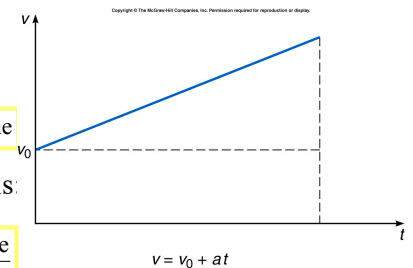
- The velocity increases with time.

$$\text{Acceleration} = \frac{v - v_0}{\text{time}}$$

$$v = v_0 + \text{acceleration} \times \text{time}$$

- Average velocity is:

$$\bar{v} = v_0 + \frac{\text{acceleration} \times \text{time}}{2}$$



Acceleration from rest

- Let us consider the case where a particle accelerates from rest at a constant acceleration a :
- The initial velocity is $v_0 = 0$
- The final velocity is $v_1 = at$
- The average velocity is $\bar{v} = (v_1 + v_0) / 2 = at / 2$
- Thus the displacement is $d = \bar{v}t = (at / 2)t = at^2 / 2$

Accelerating from rest

- Starting at rest $v_0 = 0$
- Thus $v_1 = at$
 $\bar{v} = v_1 / 2 = at / 2$
 $d = \bar{v}t = at^2 / 2$
 $t = \sqrt{2d / a}$

Constant Acceleration (II)

- Distance traveled can be calculated using the average velocity:

$$d = \bar{v} t \quad \text{distance} = \text{average velocity} \times \text{time}$$

- Using the average velocity from previous slide:

$$\bar{v} = v_0 + \frac{\text{acceleration} \times \text{time}}{2}$$

- Distance traveled

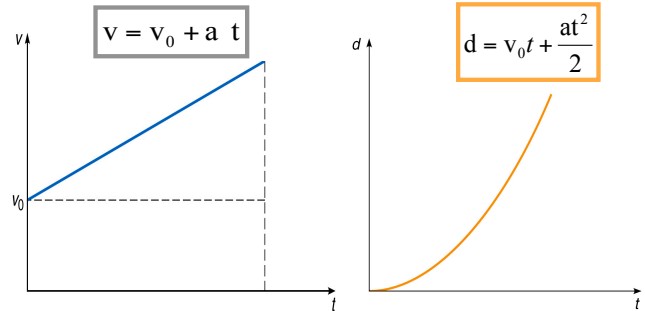
$$d = v_0 t + \frac{at^2}{2}$$

Gravitational Acceleration

- Near to the Earth's surface objects either **dropped or thrown up** into the air will experience a **constant acceleration** of magnitude 9.8 m/s^2 (or 32 ft/s^2).
- If the positive direction is taken as “up”, the gravitational acceleration is negative.

Constant Acceleration (III)

Graphically:

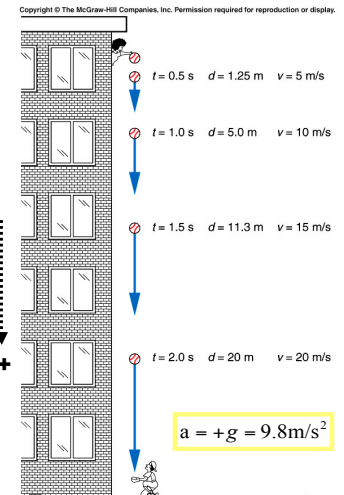


Falling Objects

- If you **drop** a ball it will have:
 - zero initial velocity
 - an acceleration of 9.8 m/s^2 due to gravity (downward therefore positive).
- The velocity and position can be written as:

$$v = a t$$

$$d = \frac{at^2}{2}$$



Throwing a ball downward

- If you **throw** a ball, it will have
 - a non-zero initial velocity (downward therefore positive)
 - an acceleration of 9.8 m/s^2 due to gravity (downward therefore positive)

$$v = v_0 + a t$$

$$a = +g = 9.8 \text{ m/s}^2$$

$$d = v_0 t + \frac{at^2}{2}$$

Throwing a ball upward

- If you **throw** a ball, it will have
 - a non-zero initial velocity (upward therefore positive)
 - an acceleration of 9.8 m/s^2 due to gravity (downward therefore negative)

$$v = v_0 + a t$$

$$a = -g = -9.8 \text{ m/s}^2$$

$$d = v_0 t + \frac{at^2}{2}$$

Throwing a ball upward

$$v = v_0 + a t$$

$$d = v_0 t + \frac{at^2}{2}$$

$$a = -g = -9.8 \text{ m/s}^2$$

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